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Steel, Wrought Iron and Corrosion
—A Review. —

Compliments of
Reading Iron Company,
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Philadelphia, Pa.

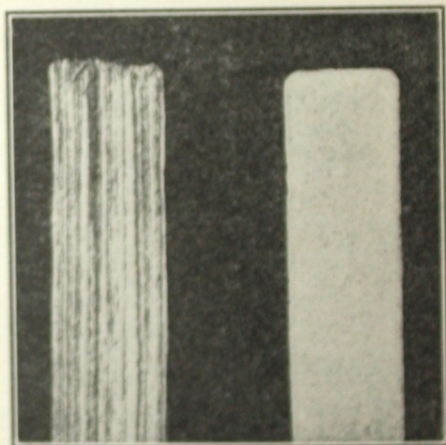
28 Platt St.,
New York City.

during the process of rolling, giving wrought iron a fibrous structure. This inclosed cinder consists principally of silicate of iron, similar to the outer skin of iron castings. Silicate of iron resists ordinary corrosion better than pure iron, as is proved by the greater rust-resisting power of cast iron. The presence of these fibers of silicate of iron (cinder) in wrought iron is responsible for its having greater resistance to corrosion than steel.

Just as paint is a protection against corrosion on the outside of the metal, so the cinder fibers permeating wrought iron are a protection in the interior of the metal. A wrought-iron bar is like a wire rope in which each individual wire has been painted before the rope was put together.

WROUGHT IRON

STEEL



Appearance of Iron and Steel After Immersion 15 or 20 Minutes
in a Solution 9 Parts Water, 3 Parts Sulphuric Acid
and 1 Part Muriatic Acid.

Segregation in wrought iron is impossible, as, on account of the plastic state of the mass, any impurities that may be present are held captive wherever they are, without any chance to flock together, similar to the way in which other ingredients are held captive in dough or putty, while in a liquid they are at liberty to float together.

After the original sponge has been rolled out into bars (muck bars), these are cut up, piled one upon another, reheated, and then welded together and rolled out again. This not only mixes

the bars of the same heat, but bars of other heats are mixed in with them, so that the finished iron will be more of an average quality and more nearly uniform than steel.

Steel is rolled out of the original ingot to the finished product without any overlapping or the mixing in of steel of other heats; therefore, whatever chemical irregularities exist in the original ingot, the same irregularities will still exist in the finished strip, no matter how long it may be. This accounts for what Mr. Fleming calls the "notorious irregularity of steel" in "the same batch of stuff," meaning that made from the same ingot.

CORROSION TESTS.

Experts differ as to the exact cause of corrosion. Some attribute it to electrolytic action, while others claim it is simply a dissolving of the metal by oxidation. What makes the problem still more difficult to solve is the fact that corrosion frequently acts very capriciously, sometimes concentrating itself on certain spots (pitting), while at other places and under apparently the same conditions it will diffuse itself over larger areas.

After experience in actual practice had demonstrated the fact that steel rusted out much faster than the old-fashioned puddled wrought iron, the steel manufacturers naturally tried to find the cause, with a view to increasing the durability of steel, if possible. As stated farther on, they experimented by varying the different ingredients, but the problem is to find a quick and at the same time a reliable method of testing durability under ordinary conditions.

Paradoxical as it may seem, it has nevertheless been conclusively demonstrated that while silicate of iron will resist corrosion due to ordinary exposure much better than pure iron, it will readily dissolve in a strong acid; therefore, if we put a piece of wrought iron in acid, the dissolving of the silicate of iron (which is distributed between the iron fibers) will open up new surfaces for the acid to attack the iron. This explains why steel, which is practically free from silicate of iron, will in most cases resist strong acid better than wrought iron; in other words the silicate of iron acts as a rust protector the same way as a thin coat of paint, for, if we pour a strong acid on paint we also destroy its usefulness.

Here we have the most important feature of this whole controversy. The claims made by the manufacturers of the different brands of soft steel sold under various mystifying names are based almost entirely on accelerated corrosion tests made on either small samples in a laboratory or in extraordinary service where the acid nature of the surrounding conditions will cause a quick dissolution of the silicate of iron.

TESTIMONY FROM INVESTIGATORS.

It is of the utmost importance to bear these facts well in mind in order to discriminate justly between the claims of superiority of a new metal based on accelerated corrosion tests and the proof of actual service of many years' duration. Our contention will be made more clear by some extracts from the conclusions arrived at by a few of the investigators of this subject. R. C. McBride reports as follows on the results of tests he made:

The first example examined was a piece of sheet iron roofing which was known to have been in service for more than 40 years, and in that time to have received but two coats of paint. Here was a chance to make an "accelerated" test on a sample which had already demonstrated its ability to resist the conditions of actual service. A carefully cleaned piece was submitted to the action of $2\frac{1}{2}$ per cent. sulphuric acid at room temperature for 24 hours. To our surprise the sample showed a loss of 71 per cent. in weight. . . . The analysis shows it to have been the real old puddled iron.

At the end of the "accelerated" test, the iron presented a very marked foliated structure, which viewed edgewise resembled a stone wall from which all the cement has been removed. This peculiar appearance at once suggested that the slag had been attacked and dissolved out more readily than the iron. . . . This seems to support the old theory that the weather-resisting power of puddled iron was largely due to the protective action of inclosing layers of slag . . . while the greater susceptibility of this iron to "accelerated" corrosion is due to the fact that the diluted acid employed readily attacks this protective coating and, by opening up the foliated structure in this way, multiplies the surface exposed to corrosive action. It is well known that slag resists, almost to the point of immunity, the corrosive agents of actual service.

Dr. William H. Walker, after making a comparative accelerated corrosion test of iron and steel, concludes:

The results show that no reliance can be placed in the accelerated acid test, but that it may be entirely erroneous and very misleading. Not only did the acid test not agree with the service test when steel was compared with iron, but the steels failed to agree among themselves, and the irons showed no agreement when considered by themselves.

According to Dr. Allerton S. Cushman:

Purchasers should not allow themselves to be influenced by the showing made by a series of laboratory acceleration tests.

The general experience in service lasting over considerable periods of time and the accumulated tests made by a number of different investigators do not justify any such conclusion [as has been drawn from such tests].

L. J. Campbell, Youngstown, Ohio, says:

These accelerated tests have been so generally discredited and so strongly denounced that it would seem a waste of time to dwell upon them were it not for the fact that they form the sole argument upon which merit claims are made by the manufacturers of these so-called open-hearth "irons" and non-corrosive metals.

THE PROOF OF ACTUAL SERVICE.

With the accelerated corrosion tests proven unreliable and misleading, the only safe guide left is the one of actual use under ordinary service conditions. We therefore quote a few examples from practical experience.

R. H. Gaines stated in the *Engineering News* of May 28, 1908, that a large water conduit made of wrought-iron sheets 3-16 to $\frac{1}{4}$ in. thick, many miles in length, laid near the city of Rochester, N. Y., in 1874, required not a cent for repairs for the first 19 years; that between 1894 and 1904 a few leaks due to corrosion appeared (less than ten), and none have been reported since. In 1890 another conduit was laid near the old one. This was made of steel sheets $\frac{1}{4}$ to $\frac{3}{8}$ in. thick. This steel conduit began to leak in 1900 and has been developing new holes ever since, so that 164 holes had been repaired by 1907, notwithstanding the frequent digging up of the conduit for renewal of painting, japanning, tar coating, etc., and also notwithstanding the fact that some of the steel sheets were twice as thick as the wrought iron. We have since been advised that up to 1909 only three sheets of wrought iron in all had been pitted, while the steel conduit was pitted in 350 places. Mr.

Galves quotes similar experiences of corrosion of steel in connection with the municipal water supplies of Portland, Ore., Cambridge, Mass., New Bedford, Mass., Pittsburgh and Allegheny, Pa., the East Jersey Water Company, and Atlantic City, N. J.

James P. Roe, Pottstown, Pa., writing on June 7, 1912, says:

A wrought-iron stand pipe erected in 1896 at Sea Isle City, N. J., 10 ft. in diameter by 100 ft. high, was in such good condition in 1911 that 25 ft. was added to top, by which pressure and service were increased. A steel stand pipe erected in 1897 at Avalon, N. J., four to five miles away from above, corroded through and out of service in 1911. Now being replaced with wrought iron.

In the Indiana gas belt two parallel pipe lines were taken up on account of the gas giving out. Each line was 25 miles long, and the two lines had been laid side by side in practically the same soil and had transported the same kind of gas. The wrought-iron pipe was 8 in. in diameter and had been in service 18 years, while the steel pipe was 6 in. in diameter and had been in service only 11 years. While 24½ miles (over 96 per cent.) of the wrought-iron pipe was still in good condition after being taken up, 1200 ft. (nearly 1 per cent.) was corroded so as to make it unfit for further use. On the other hand, 14 miles (56 per cent.) of the steel pipe was thrown aside for the above reason, 11 miles, or 44 per cent., being still in good condition.

Quoting again from Mr. Fleming's article in *The Iron Age* of March 14, 1912:

A steel roof often begins to leak in a comparatively short time. Examination reveals the fact that only a few of the sheets are corroded, and those only in small patches. . . . A few bad sheets condemn the whole roof. There is a conspicuous lack of uniformity in all steel roofs, especially large ones on which many sheets are used. . . . A wrought-iron roof lasts almost a lifetime. It is not the case that a small number of sheets become defective and condemn the whole roof. Every sheet is uniformly good, and when the roof is torn away, after decades of service, the sheets are found to be uniformly bad. Corrosion has done about the same damage to every one. The same facts apply to wrought-iron pipe lines.

OTHER ADVANTAGES OF WROUGHT IRON.

In addition to its greater resistance against corrosion, wrought iron has many other advantages over steel:

a. Wrought iron welds more easily and more uniformly than steel, and the danger of imperfect welds in wrought-iron pipe is reduced to the minimum.

b. Threads can be cut better and more easily on wrought-iron pipe than on steel pipe, which can easily be verified by consulting any pipe fitter.

c. Owing to its fibrous structure, wrought iron will resist vibrations and shock better than steel, making the former preferable for oil well tubing, drive pipe, etc.

d. Wrought iron has a rougher surface than steel. This will cause paint, tar, or galvanizing to stick better and in thicker layers, so that when using galvanized wrought-iron pipe, we not only have a better metal as a base, but a thicker coating of zinc in addition.

IMITATION WROUGHT IRON.

The remarks about wrought iron made in the preceding paragraphs have reference to genuine wrought iron made from puddled pig iron only. Unfortunately, there have been some irons put on the market that are made by using old junk yard scrap, heated in a furnace to a welding heat (bushelling or fagoting), and then rolled out into bars, sheets, etc. When the old scrap consisted of nothing but wrought iron, it was not so bad, because wrought iron is permeated with the cinder fibers which were produced in the puddling operation. But junk-yard scrap nowadays is mixed with more or less steel—some of it, maybe, high carbon or other alloy steel of various grades—and since steel is not permeated with cinder fibers, when these pieces get rolled into the iron, you have a starting point for corrosion or pitting. We fear that some of this kind of iron has been paraded as genuine wrought iron and in some cases picked out when making comparisons with modern steel.

EFFORTS TO IMPROVE STEEL.

Ignoring the fact that the physical structure of wrought iron with its inclosed cinder fibers is the cause of wrought iron's greater resistance against corrosion, many metallurgists have been experimenting with steel by varying the proportion of the ingredients. Some claimed that manganese was the sole cause of the trouble, and therefore they tried to keep it as low as possible. Others claimed that manganese will kill the alleged

microbe of the rust disease (occluded oxygen), and therefore they increased its percentage. Again others claim that copper will help to resist corrosion and point to accelerated corrosion tests as proof; while yet other experts consider that copper only serves to retard the acid test and confuse the unsophisticated.

So-called "Spellerized" steel was put on the market a few years ago, and a better resistance to corrosion than ordinary steel possesses was claimed for it. At first the process was kept a secret, but repeated challenges finally brought forth the statement that the treatment is mechanical only—that it consists simply of rolling ridges and depressions into the skelp (sheets from which pipe is made) on its second or third last pass through the rolls (similar to the rough surface one sees on steel sheets when used for cellar doors, etc., on sidewalks), and then rolling them out again by passing it through smooth finishing rolls. It is claimed that this process kneads the surface and makes it denser. While we believe that this roughening and smoothing out again have absolutely no effect on the finished skelp, we do know that, even if it did make the surface denser, the skelp must subsequently be reheated to a welding heat in the tube welding furnace, and that this heat treatment will restore the texture of the steel to its original condition. Furthermore, as stated in an earlier paragraph, the irregularity of steel in its resistance to corrosion is due to its irregular chemical composition, and the irregularity in the chemical composition of the original steel ingot still exists in the finished pipe. No amount of mechanical treatment can change this chemical irregularity. It can, therefore, be plainly seen that the claim that this process will increase the rust-resisting qualities of steel is utterly fallacious.

As it is much cheaper to make steel by refining the raw material in a fluid state, either in the open-hearth furnace or the Bessemer converter, than to refine it by the old style of puddling pig iron, it is but natural for the steel maker to wish that this greater rust-resisting quality of wrought iron were due to its chemical composition rather than to its physical structure. Ignoring segregation, the former can easily be approached in the open-hearth furnace, but the latter can never be imitated by any steelmaking process that refines the metal in a fluid state. We may as well attempt to roll out molten lead and

give it the texture of a woven fabric. Calling such steel "Spellerized Steel," "Wrought Pipe," "Open Hearth Iron," "Ingot Iron," "Vismera Iron," "Toncan Metal," or any other mystifying name, will not give it the fiber. The only way these life-prolonging cinder fibers can be produced in the metal is by the puddling process.

SOME EXCUSES FOR STEEL CORROSION.

When the fact of the more rapid corrosion of steel pipe and sheets in ordinary use could no longer be denied, the explanation was offered that "steel has come into wide use simultaneously with the great increase of the sulphurous acid in our city air and of strong electric currents in our city ground, which may well lead the practical man, be he hasty or cautious, into inferring that the rapid corrosion of today is particularly due to the new metal of the day, steel, whereas in fact it may be wholly due to the new conditions of the day, sulphurous acid and electrolysis."

At a meeting of the Engineers' Society of Western Pennsylvania in 1907, a statement was made similar in effect to the one quoted above, and in the discussion that followed K. F. Stahl called attention to the rapid corrosion of steel due to a change his company made some years ago, as follows:

We extended a building and used the old sheets, which had been in use for eight or nine years, on the sides of the old building which we extended. On the ends we used new steel sheets, and I found after four or five years the steel sheets were considerably corroded, while the old iron sheets were still good.

So here we have an example of old iron sheets, which had already done service for eight or nine years, when exposed to the influences of this very self-same modern corrosive atmosphere outlasting the new steel sheets, which corroded in four or five years.

Another statement, made before a meeting of the New England Water Works Association in Boston in December, 1911, was to the effect that, due to the better treatment of municipal water supply, by filtration, etc., the water nowadays is much purer than formerly, and that the purer the water the harder it is on the pipe. Mr. Hazen, the president of the association, in referring to this claim, said:

At the same time, we find that in many important enterprises, where people are studying the conditions very carefully, they think they had rather have wrought-iron pipe, and they are willing to pay a substantial increase in price in order to get it.

ANALYSIS OF CLAIMS FOR STEEL PIPE.

Some years ago T. N. Thomson, Scranton, Pa., made some tests by putting a few short pieces of 2-in. wrought-iron pipe and steel pipe alternately into a hot-water service line. After one year's use he measured with a micrometer the depth of the depressions supposed to have been caused by corrosion, and then made calculations to ascertain how much longer each pipe would have lasted before perforation would take place. He concluded that steel pipe would last 54 7-10 days longer than wrought-iron pipe. The total amount of pipe tested was about 10 ft. When we consider the capriciousness of corrosion and the variations in the quality of steel, it must be admitted that such a miniature test is of no value, compared with the evidence of actual service of larger pipes, miles in length, weighing thousands of tons, and where corrosion continued until the holes penetrated the metal. Although this test has been declared valueless by other experimenters, as well as by technical journals, yet it is the table of this very experiment that is repeatedly being published in attempts to prove the superiority of steel.

Another favorite exhibit by the champions of steel is to show pictures of pipe laid in mine water; but considering that the water in some mines is very acid, and in view of what has been said above under the head of "Corrosion Tests," this also is valueless as a guide to behavior under ordinary service conditions.

The report of Prof. Ira Woolson on the condition of wrought-iron and steel pipe in some public bath houses in New York City, as published in the advertising columns of some technical journals, mentions the fact that:

Out of 89 samples collected, fully 17 were undoubtedly wrought iron. The wrought-iron pipe was mixed indiscriminately among the steel pipe, and there was no way of telling one from the other until tested, although investigation of the specifications showed that all except two called for galvanized wrought-iron pipe. The probable explanation of the presence

of steel among the wrought iron is that the pipes were accidentally mixed, either by the manufacturers or the jobbers.

Now, if this pipe was furnished by manufacturers or jobbers unscrupulous enough to mix over 80 per cent. of steel pipe into a lot of pipe sold as wrought iron, they certainly would not hesitate to furnish so-called wrought-iron pipe made of junkyard scrap, as mentioned above, and it need therefore surprise no one that such pipe was as susceptible to the attack of corrosion as steel pipe.

RECAPITULATION.

Having explained the great irregularity in the behavior of steel under the same conditions, due to the irregularity of the metal, and furthermore that there are so many other influences at work that cause variations in the corrosion of metal of even as uniform a quality as wrought iron, the explanation becomes very easy why some few pieces of steel pipe can be found occasionally that have resisted corrosion very well, while under apparently identical conditions wrought iron has been corroded.

Should we make a scientific examination of a sample of the corroded wrought-iron pipe in the Indiana gas belt as cited above, and also of a sample of the steel pipe of the parallel line which was still in good condition, a big essay could be written on the superiority of steel. Yet as a matter of fact the damage done by corrosion of the steel pipe in 11 years was over 55 times greater than the damage done to the wrought-iron pipe line in 18 years. We must not be misled by a few isolated failures, but take the majority of cases as a guide.

We admit that under favorable conditions some steel pipe has given good service, while other steel pipe has corroded very rapidly; but, owing to the admitted irregularity of steel in its resistance against corrosion, nobody can predict how any particular piece of steel pipe is going to behave. You may get pipe that will last, and you may not.

Mr. Fleming, in his article published in *The Iron Age* of March 14, 1912, extolling the virtues of a new soft steel which had been christened "Genuine open-hearth iron," admits that "wrought iron in service resists corrosion better than steel. This truth is demonstrated by an overwhelming mass of practical evidence." In view of the fact that all of these alleged rust-resisting steels or so-called "irons" are of comparatively

recent invention, the practical evidence of their long service is naturally lacking. The arguments are based on accelerated corrosion tests, which have been proved entirely misleading.

Don't let us forget that none of these steels contains the cinder fibers which give wrought iron its longer life. The claims of the manufacturers that making a few slight changes in the chemical composition of their steel, or giving it some peculiar mechanical treatment, will prolong its life are simply a fond hope, in which the wish is father to the thought. The proof of behavior during many years' actual service is at this time a physical impossibility.

Let us pause for just a moment and consider that in the case cited above by Mr. Gaines, the steel (which was not "Spellerized") lasted ten years before the first perforation occurred; that it required 20 years before the thinner wrought iron had a hole, and that the wrought-iron conduit has now been in use nearly 40 years. How can anybody prove now that his new steel or "ingot iron," or whatever it may be called, will last as long as wrought iron, or even as long as the ordinary steel, or tell what its condition will be ten years hence?

Be on the safe side and use a metal that has withstood the test of actual use for these many years.

It will not cost any more to dig the trench for wrought-iron pipe than for steel pipe; the pipe fittings will cost the same; and, considering that wrought-iron pipe threads more easily than steel, it really ought to cost less to put it in place, as there are fewer splits due to imperfect welds, which require rethreading, etc. The only difference is in the cost of the pipe itself. The expense and annoyance of replacing rusted out pipes inside of walls or under floors more than offset the small difference in first cost of genuine wrought-iron pipe.

GEORGE SCHUHMAN,

General Manager Reading Iron Company.

READING, PA., October 30, 1913.

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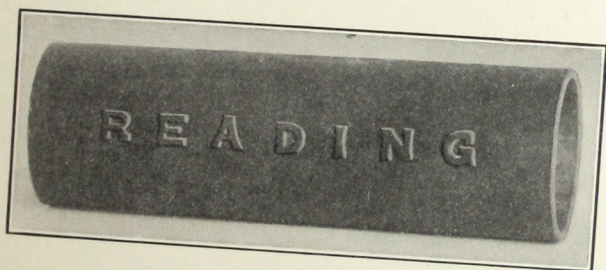
The READING IRON COMPANY is the largest manufacturer of wrought iron pipe in the country. We make our pipe from the ore to the finished product. We use no junk, but make our pipe from pig iron puddled in the old-style puddling furnaces. We court full inspection.

We now roll the name "READING" in all our pipes. The name will appear in slightly raised letters as shown in the illustration below, except that in redrawn butt-welded pipe, which is mostly used for coiling purposes, the name is slightly depressed.

It has not yet been found advisable to roll the name into boiler tubes, for the reason that the slight depression caused by the rolling in of the name may just happen to come in the portion passing through the flue sheet; therefore we shall continue for the present to stencil our name on the boiler tubes of our manufacture.

In ordering pipe, be sure to specify "Genuine wrought iron pipe made from puddled pig iron only; the use of scrap or steel in any shape in its manufacture is prohibited."

We do not manufacture any steel pipe; therefore dealers and consumers can rest assured that our shipping department cannot "accidentally" mix steel pipe with iron pipe, as happened in the case of the N. Y. bath houses mentioned above. The word "READING" rolled into our pipe is guarantee that the same is made of genuine wrought iron made from puddled pig iron.



READING IRON COMPANY.

READING, PA., January 1, 1914.

Our pamphlet, "Court of Actual Experience," contains further testimony of the greater durability of Wrought Iron, as well as more data about Corrosion Tests, Physical Tests, etc., and our monograph on "Iron & Steel" gives the outlines of the manufacture of these metals in such language as to be easily understood by the non-technical reader. Both will be mailed on application.

